Nutrient mediated interaction between above- and below-ground herbivores of poinsettias

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Abstract

Understanding the relationship between above and below ground herbivores and how this interaction is mediated by nutrition can lead to the development of more efficient insect management methods. We evaluated the effect of two nitrogen levels on the interaction between darkwinged fungus gnats (DWFG), ***Bradysia difformis***, and silverleaf whitefly (SLWF), ***Bemisia tabaci*** biotype B, on poinsettias, and their combined effect on plant performance. Plants were infested three days after transplant with whiteflies, and ten days after transplant with fungus gnats. The effects on SLWF were measured by evaluating developmental time and F1 oviposition. Pupae numbers remaining in the soil and adult emergence were measured for DWFG. Herbivore impact on plant performance was evaluated by measuring total plant dry weight and photosynthesis. Our results show that SLWF was positively impacted by the presence of DWFG as SLWF F1 oviposition was higher when DWFG were present. This relationship was mediated by nutrition as we found stronger effects when the plants were grown at the high nitrogen level (150 mg/L). Conversely, DWFG were negatively impacted by SLWF presence. There were fewer DWFG pupae found in the soil when SLWF were present. However, DWFG emergence was not influenced by SLWF presence. Overall, our data supports the hypothesis of competition effects between SLWF and DWFG. SLWF benefited from the competition while DWFG were negatively impacted. The presence of both herbivores affected total dry weight of poinsettias, especially when they were grown at the low nitrogen level (50 mg/L) but photosynthesis rate was not affected.

Introduction

❖ Studying species interactions is important to understand community structure and ecosystem dynamics (Arthur and Mitchell, 1989). However, most studies focus on above-ground interactions, without considering the below-ground subsystem.

❖ This study uses poinsettias and its two most common pests, silverleaf whitefly (SLWF) as the above-ground herbivore; and the darkwinged fungus gnat (DWFG) as the below-ground herbivore (Ecke *et al.* 2004) (Fig.1).

❖ Herbivore competition effects can impact pest management practices, for instance exacerbating damage by one pest. Thus, it is very important to understand these relationships for successful integration of management tactics.

Thus, the objectives of this study were to:

❖ Determine the relationship between above- and below-ground herbivore. We hypothesized there will be a positive impact on the SLWF and negative impact on the DWFG.

❖ Determine impact of two nitrogen levels on the competition. We hypothesized that nitrogen level would affect this relationship.

❖ Determine the impact of the competition on plant performance. Our hypothesis is that the combined effect of both herbivores will negatively impact plant performance.

Figure 1. a) Silverleaf whitefly nymphs, *Bemisia tabaci* biotype B. b) Darkwinged fungus gnat larvae, *Bradysia difformis*.

Methods

Figure 2. Partial view of the experimental design. Poinsettia plants (*Euphorbia pulcherrima*) being irrigated with an ebb and flow system (sub-irrigation).

Experimental design and treatments: a split plot design with 2 main plots = 2 nitrogen levels (50 mg/L and 150 mg/L); 4 sub plots = 3 insect infestation ((1) DWFG, 300 2nd instar larvae; (2) SLWF, 60 pairs; (3) DWFG+SLWF) + control, plant without pests (Fig. 2).

SLWF: A) Infestation: Three days after transplant, 60 pairs were allowed to oviposit for 24 hours (ca. 360 eggs), after hatching 48 nymphs were marked and followed throughout their life (Fig.3). B) Measurements: Developmental time and F1 oviposition.

Figure 3. a) Plants with clip cages containing five SLWF pairs each. b) Nymph development was evaluated every other day.

Figure 4. a) Sticky cards used to measured DWFG adult emergence. b) Flotation technique used to recover pupae.

DWFG: A) Infestation: Ten days after transplant plants were infested with 300 2nd instar larvae to match SLWF development. B) Measurements: adult emergence and pupae numbers remaining in the soil (Fig.4).

Plant measurements: total dry weight and net photosynthetic rate.

Data analysis: SLWF development was analyzed using LIFETEST (a nonparametric test, comparing survival curves) and F1 oviposition (SAS Institute, 2005). DWFG pupae numbers, DWFG adult emergence, total dry weight and photosynthesis were analyzed using split plot ANOVA (PROC MIXED, SAS Institute, 2005).

Results and Discussion

❖ The survival distribution functions for the SLWF and SLWF/DWFG treatments at 50 mg/L nitrogen level were not significantly different from one another (log-rank statistic = 0.0119, P = 0.9130), but there was a difference between the two treatments at 150 mg/L nitrogen level (long-rank = 2.8723, P = 0.0901; Fig. 5). Poinsettias with SLWF/DWFG showed lower survival.

❖ Conversely, SLWF F1 oviposition showed that the nitrogen level by insect treatment interaction was significant different ($F_{1,8}$ = 7.2; P = 0.0270) (Fig. 6). Poinsettias with SLWF/DWFG showed higher F1 oviposition.

❖ The high F1 oviposition of the SLWF on the SLWF/DWFG treatment may be due to a compensatory response of the SLWF to the lower survivorship observed, suggesting a positive impact on the SLWF offspring population.

❖ There was no significant interaction between nitrogen level and insect treatment in DWFG adult emergence ($F_{1,8}$ = 0.38; P = 0.5555).

❖ The interaction between nitrogen level and insect treatment was significant when DWFG pupae numbers remaining in the soil was analyzed ($F_{1,8}$ = 9.41; P = 0.0154) (Fig. 7). More pupae were found when DWFG was alone but only at the 150 mg/L nitrogen level.

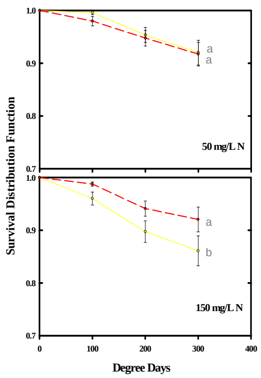

Figure 5. SLWF Survival Distribution Function. The dashed line (- -) represents SLWF treatment and the solid line (—) represents SLWF/DWFG treatment.

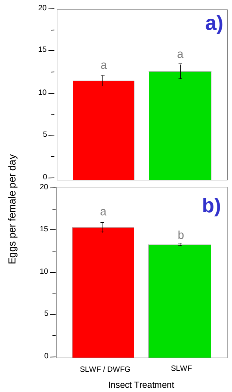

Figure 6. SLWF F1 oviposition. a) 50 mg/L nitrogen level; b) 150 mg/L nitrogen level.

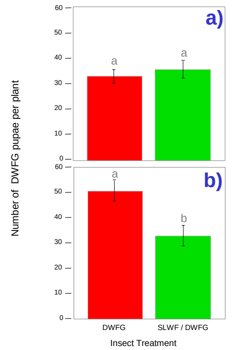

Figure 7. DWFG pupae numbers remaining in the soil. a) 50 mg/L nitrogen level; b) 150 mg/L nitrogen level.

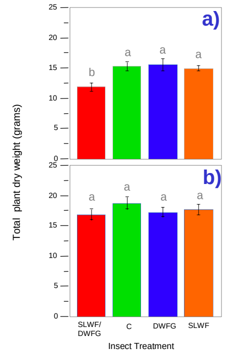

Figure 8. Total plant dry weight. a) 50 mg/L nitrogen level; b) 150 mg/L nitrogen level.

❖ Both herbivores showed a better performance at the higher nitrogen level (150mg/L), confirming previous finding on SLWF by Bentz *et al.* (1995).

❖ The net photosynthetic rate of poinsettia was not affected ($F_{3,23}$ = 2.93; P = 0.0550).

❖ The interaction of the total dry weight between the nitrogen level by the insect treatment was marginally significant ($F_{3,24}$ = 2.97; P = 0.0520) (Fig. 8). Total plant dry weight may be compromised when both herbivores were present at the lower nitrogen level (50 mg/L).

Conclusions

❖ Our data supports the hypothesis of competition between above- and below-ground herbivores with a positive impact on the above-ground herbivore (SLWF) and a negative impact on the below-ground herbivore (DWFG).

❖ Competition between herbivores was present at the higher nitrogen level.

❖ Reduction of nutrients within the plant affected both herbivores overall performance, and plant performance was affected more when both insects were present at the lower nitrogen level.

Acknowledgements

❖ We acknowledge the assistance provided by Eliana Rosales, Karla Medina, Henry Paz, Nuris Acosta, Jim Hacker, Felix De Los Santos, Christian Cruz, and Maria del Carmen Sanchez.

❖ Plant material was kindly provided by the Ecke Ranch.

❖ This research was supported by a graduate research assistantship from the Department of Entomology, The Ohio State University.

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